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PACKAGING AND HANDLING ANALYSIS OF THE LN-31 (683420-14) INERTI--ETC(U)
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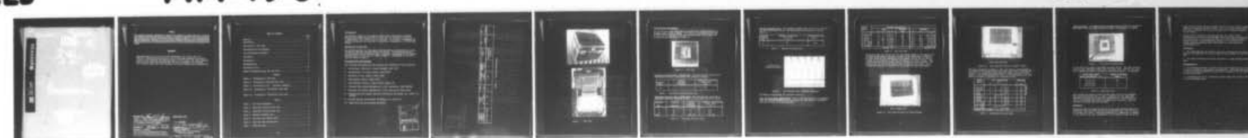

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ABSTRACT

High maintenance cost of the Inertial Measurement Unit (LN-31 IMU, P/N 683420-14, NSN 6605-00-520-5744) for the F-15 aircraft prompted the investigation of the packaging and handling aspects of this item. The rough handling tests and the field test revealed that the pack is adequate for providing the 15G shock protection level required for routine handling and transportation.

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Introduction

This Agency's survey of the Logistics Support Cost Maintenance and Repair Records (K051.PW3M) revealed that the LN-31 IMU is consistently listed as a "High Burner" cost item of the F-15 aircraft. As a result, a packaging and handling evaluation was conducted to determine if packaging is a contributing factor.

Description of Test Pack

The ATA-300 container is fabricated from high density polyethylene with steel reinforced edges and recessed handles and latches. The cushioning inserts are fabricated from polyurethane foam. Additional information on the physical characteristics of this pack is listed in Table I. Photographs of the test pack are shown in Figure 1.

Instrumentation and Equipment

The following instrumentation and equipment was employed for this evaluation:

1. Oscilloscope, Tektronic, 4 channel storage, Model 564B

2. Accelerometer, tri-axial, Endevco, Model 2233E

3. Amplifiers (3 ea), Endevco, Model 2414C

4. Power Supply, Endevco, Model 2622C

5. Electrodynamic Vibrator, Unholtz-Dickie, Model 506

6. Vibration Test Machine (mechanical), L.A.B. Corporation, Type 5000-96B

7. Vibration Test Machine (mechanical), L.A.B. Corporation, Model 41012

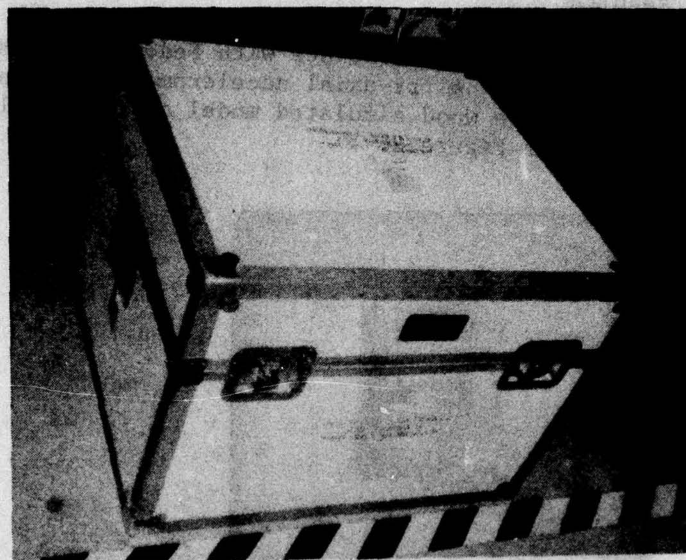
8. Transportation Environment Recorder, Bolt-Beranek and Newman Inc., Model 714, S/N 203

9. Recorder Readout, Bolt-Beranek and Newman, Inc., Model 615

10. Chain Hoist and Quick Release Mechanism

INSIDE DIMENSIONS (INCHES)	WEIGHT (LBS) NET	WEIGHT (LBS) GROSS	CUBE (FT^3)	CUSHIONING MATERIAL TH'K (INCHES)	CUSHIONING MATERIAL DENSITY (pcf)	CUSHIONING MATERIAL TYPE	NR. LATCHES	NR. HANDLES
28 X 24½ X 20½	55	93	9	5-6¼	2	POLYURETHANE (Ester)	2	2

Table 1. Test Pack Information



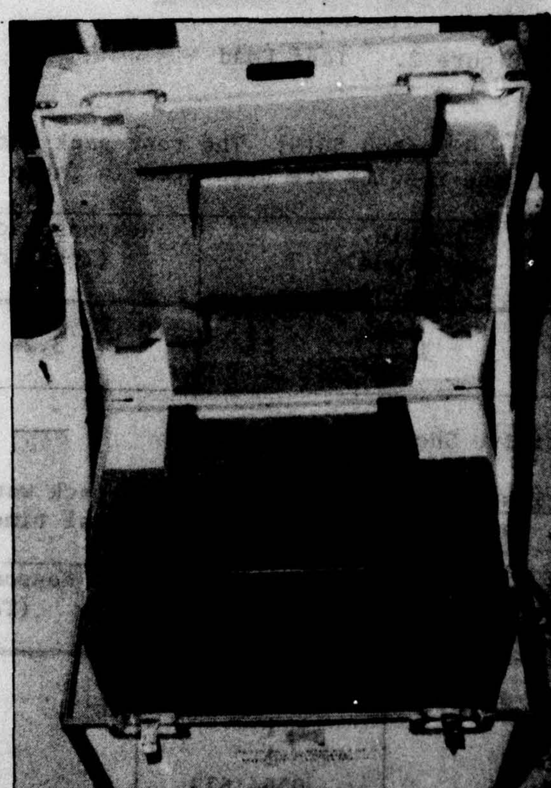


Figure 1. Test Pack

Test Procedure and Results

All of the tests were conducted in accordance with Federal Test Method Standard 101B, except as noted. A tri-axial accelerometer was located at the center of gravity of the wood simulated model of the LN-31 IMU as shown in the photograph of Figure 2.

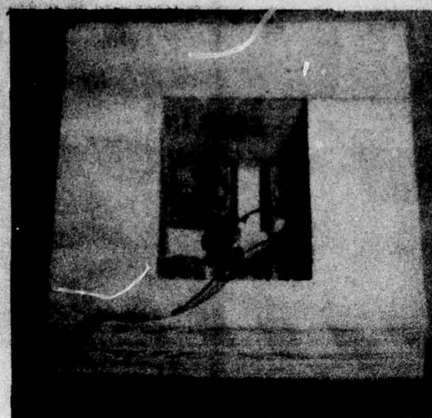


Figure 2. Test Load

Repetitive Vibration Test - Method 5019: The test pack was vibrated for a period of two hours. The results are presented in Table 2.

Frequency (HZ)	Double Amplitude (Inches)	Response Acceleration (Test Load) Gs
4.5	1	3.2

Table 2. Repetitive Shock Vibration Data

Sinusoidal Vibration Test - Method 5020: The test pack was subjected to sinusoidal vibration, as shown in Table 3, for a total time of two hours.

Frequency (HZ)	Duration (Minutes)	Double Amplitude (Inches)	Response Acceleration (Test Load) Gs
2	5	1	0.5
3	5	1	0.8
5	5	1	2.9
5-500	45	.036-.673	8.6 MAX

Table 3. Sinusoidal Vibration Data

Resonant Frequency Test: The resonant frequency data is listed in Table 4 and the oscilloscope trace of the acceleration-time history is show in Figure 3.

Resonant Frequency (HZ)	Response Acceleration (Test Load) Gs	Transmissibility Factor
14	8.5	3.28

Table 4. Resonant Frequency Data

2 Gs/cm (vert.)
50 msec/cm (horiz.)

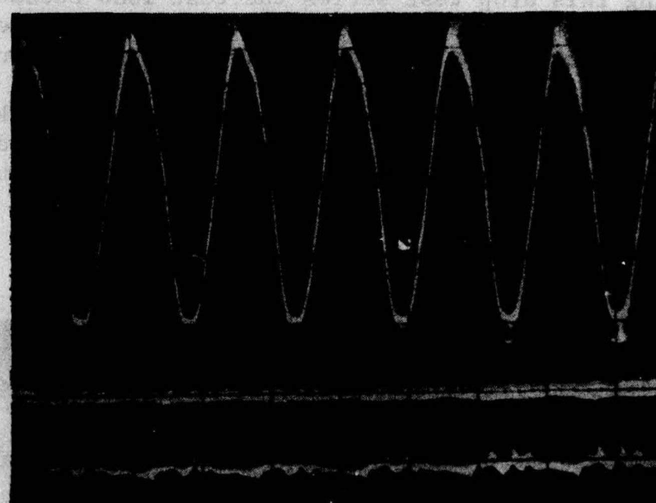


Figure 3. Oscilloscope Trace (Resonant Frequency)

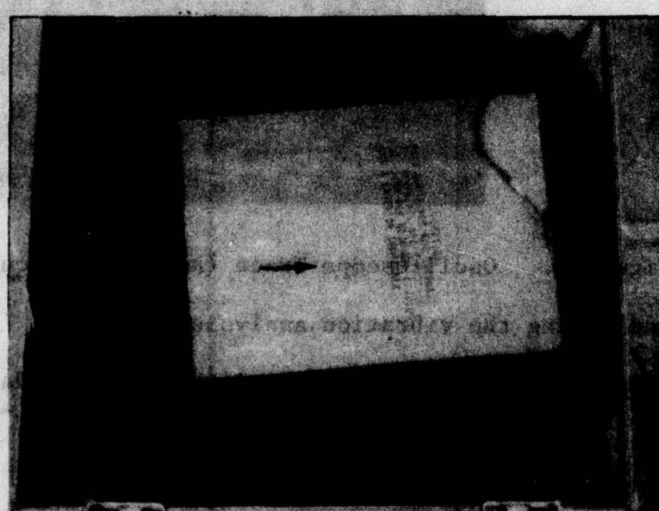
No damage occured during the vibration analysis.

Free Fall Drop Test - Method 5007: The 21 inch drop test data are compared with the Mcdonnell-Douglas test data (Report No. 668-103.BL-2) in Table 5. Note the results are in good agreement.

Impact Surface	MAXIMUM ACCELERATION - G								
	AFPEA				DURATION	MCDONNELL			
	X	Y	Z	R	(ms)	X	Y	Z	R
3 (Bottom)	0	2	12	12.2	55	1.9	2.4	10.1	10.6
1 (Top)	2	1	11	11.2	65	0	0	9.8	9.8
2 (Front)	1	10	4	10.8	75	1.9	10.6	3.1	10.6
4 (Back)	0	10	0	10.0	75	1.5	11.6	2.0	11.8
5 (L. Side)	10	0	2	10.2	75	10.1	0.4	1.6	10.2
6 (R. Side)	9	3	2	9.7	65	11.3	2.0	0	11.3
3-5 (Edge)	10	3	7	12.6	55	9.3	2.4	6.6	11.7
			Average	11.0				Average	10.9

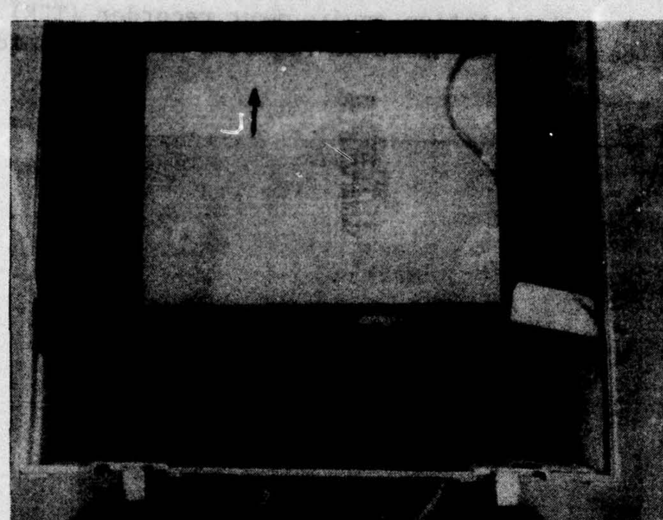
Table 5. Drop Test Data

During this drop test series the test load became wedged in the corner or to one side of the cushion cavity as is shown in the photographs of Figure 4. This was caused by the compression of the cushion inserts and the lack of rigidity of the material to restrain the load in the cushion cavity. This occured after one drop on either side or the back and front surfaces. The drops on the top and bottom surfaces did not produce this effect. This observation prompted the inclusion of the consecutive drop test series.



Drop on Right Side

Figure 4a. Test Load Off-Center of Cushion Cavity



Drop on Back Surface

Figure 4b. Test Load Off- Center of Cushion Cavity

The data is presented in Table 6. The test load was re-positioned in the center of the cushion cavity after each second drop. Although the second of two consecutive drops produced a shock level which is 36% greater, it did not significantly reduce the effectiveness of the pack which is designed to provide a 15 G protection level.

IMPACT SURFACE	MAX. ACCELERATION (Gs) X	Y	Z	R	DURATION (ms)	
3 (Bottom)	2	2	12	12.3	55	No Effect
3 (Bottom)	1	2	12	12.2	55	
1 (Top)	1	5	11	12.1	65	
1 (Top)	0	3	12	12.4	65	
2 (Front)	M I S S E D				-	
2 (Front)	1	14	4	14.6	60	
4 (Back)	0	10	2	10.2	70	
4 (Back)	3	17	5	18.0	45	
5 (L. Side)	9	0	4	9.8	70	
5 (L. Side)	15	3	3	15.6	60	
6 (R. Side)	M I S S E D					
6 (R. Side)	17	3	5	18.0	45	
AVERAGE FOR 1st DROP: 11.1, 2nd: 15.1						

Table 6. Consecutive Drop Test Data

Field Test Data: A transportation environment recorder (TER) was secured in the cavity of the test load as shown in Figure 5 and packed for shipment

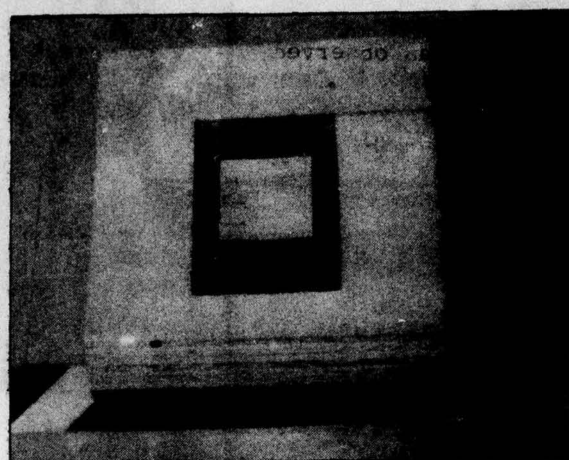


Figure 5. Test Load with TER Recorder

to Luke AFB AZ via Logair from Wright-Patterson AFB OH. The route included stops at Scott, Whiteman, Tinker, Hill and Nellis AFB. Data for the return trip to Wright-Patterson is included in the data of Table 7. A resultant

SHOCK LEVEL RANGE (PEAK ACCELERATION - Gs)	NUMBER OF RECORDED SHOCKS
2.5 to 5.0	140
5.0 to 7.5	7
7.5 to 10.0	4
10.0 to 12.5	3

Table 7. Field Test Data

type recorder was used to collect the test data for this test shipment. This instrument records the x, y and z components of each impact and immediately computes and records the resultant force. The majority of the low level shocks are caused by transportation vibration. Only the resultant values are shown in the table.

Discussion

During the drop test series one of the two cam lock fasteners came loose (unlatched) after the fifth drop and both fasteners came loose at the end of the drop test series. This was attributed to a combination of bending of the fastener lips and a compression of the container tongue and groove.

Cargo tie-down straps will also compress the two sections of the containe together and allow the latches to open. This is a typical problem with this type of fastener and it occurs on many of the containers evaluated by this agency.

During the pack analysis it was observed that the cushion inserts included many cut-outs and beveled edges which would require considerable fabrication time. It is recognized that the cut-outs were necessary to provide the proper load bearing area; however, it is believed a less complex design is feasible which could result in a cost savings of approximately 25%.

Conclusions

1. The rough handling tests and the field test revealed that the pack is adequate to provide the 15 G shock protection level required for the LN-3 IMU.

2. The camlock fasteners can become unlatched in a rough handling enviro ment.

Recommendations

1. The container fastener lip depth and the strike depth should be incre to prevent accidental unlatching of the mechanism. This modification may or may not include increasing the cam travel to compensate for the additi lip and strike depth.

2. Investigate the use of a simplified cushion design for the LN-31 IMU to reduce packaging costs.

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High maintenance cost of the Inertial Measurement Unit (LN-31 IMU, P/N 683420-14, NSN 6605-00-520-5744) for the F-15 aircraft prompted the investigation of the packaging and handling aspects of this item. The rough handling tests and the field test revealed that the pack is adequate for providing the 15 G shock protection level required for routine handling and transportation.

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